Space Weather Technical Forecast

Issued on Tuesday, 14 June 2022 at 13:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-flares. Slight chance of G1/Minor Storms Day 1 and 3 (14 & 16 June), chance of G1/Minor Storm and slight chance of G2/Moderate storm day 2 (15 June). Slight chance of Active fluence Days 3 and 4 (16-17 June).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low in the last 24 hours, with several C-class flares, the brightest of which was a C8.5 on 13/2124 UTC originating from AR3031. There are seven sunspot regions on the visible disc, the largest and most complex of which is AR3031 in the south centre disk. A large CME was observed in association with a M3 flare early 13th. While the bulk of the ejecta is expected to miss the Earth, the results suggest a possible glancing blow in the early hours of the 15th.

Solar Wind / Geomagnetic Activity: The solar wind speed, as observed by DSCOVR at L1, varied between 430-540 km/s. Density was mostly average with a period above average between 13/200-14/0400 UTC with a maximum density of 15ppcc. The Total Interplanetary magnetic field strength, Bt, was mostly moderate but on a slight declining trend . The north-south component, Bz, varied weakly between +8/-6 nT. The phi angle was mostly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) was at Background levels. Electron flux (greater than 2MeV) was also at background levels. Corresponding 24-hour integrated electron fluence has been well below the Active (1e8 integrated pfu) threshold on a slight rising trend. 3e6 integrated pfu was observed at 14/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low with C-class flares and a chance of becoming Moderate with isolated M-class flares.

Solar Wind / Geomagnetic Activity: A large CME was observed leaving the sun in the early hours of the 13th, in association with a long duration M3 flare. Its analysis revealed that while the bulk of the ejecta is expected to miss behind Earth's orbit, there is chance of a glancing blow early on the 15th +/- 9 hours. Solar wind speeds are expected to remain at slightly elevated to elevated levels on Day 1, under the waning influence of a coronal hole. They should then become elevated or perhaps strong either late on Day 1, but more likely Days 2 and 3 (15th and 16th) under the influence of the CME, followed by the high speed stream originating from CH91/+ and then CH90/+. Solar winds slowly easing on Day 4. Geomagnetic activity is expected to be mainly Quiet on Day 1 with a slight chance of G1/Minor Storm intervals at the very end of the day. G1/Minor Storm intervals are then more probable on day 2 (15th) with a slight chance of G2/Moderate Storm intervals. Day 3 (16th) will likely become Quiet to Active with a slight chance of G1/Minor Storm intervals due to the lasting effects of the CME CH90/+. Day 4 is expected to become mostly Quiet.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10 MeV) is expected to be at background or just above background levels during this period. High energy

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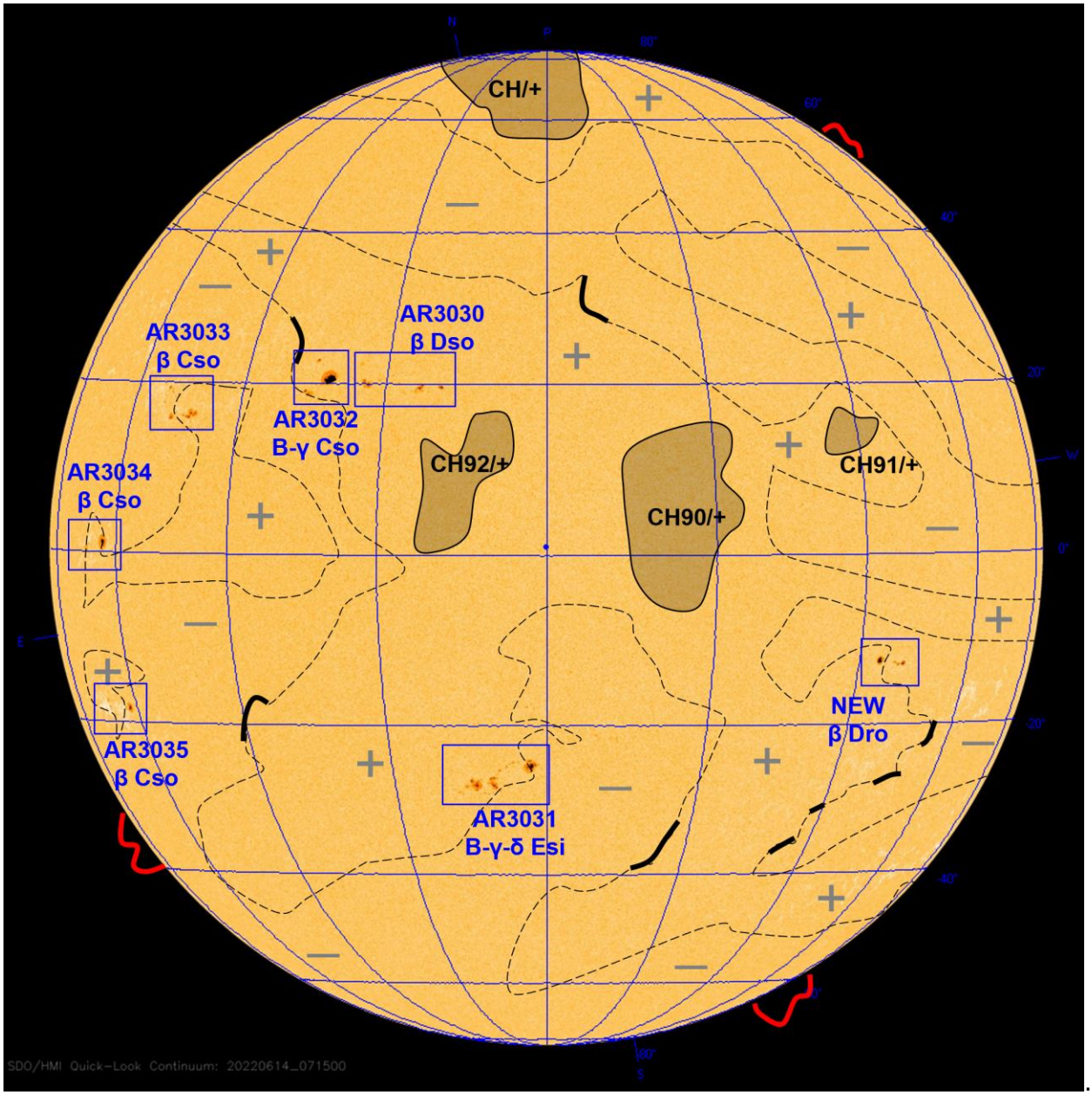
electron flux (greater than 2 MeV) is expected to start at background levels with a chance of increasing to moderate or perhaps high levels later in the period, due to high speed stream influences. Electron fluence is expected to follow a rising trend, with a chance of reaching Active (1e8 integrated pfu) levels later in the period.

Figure 1. Solar Analysis Valid 14/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There remains a risk of a glancing blow from the large CME which left the Sun on the 13th, arriving on 15th. The speed of this CME was analysed to be around 1100 km/s as is left the sun any may bring strong winds speeds at earth, approx. 550-650 km/s should it arrive. There is currently a large degree of uncertainty around this but the most likely situation is for G1/Minor storm intervals and a slight chance of G2/Moderate Storms, though the percentage risk reflects the disparity of solutions.

Coronal hole 91/+ may arrive early on Day 2, with Coronal hole most likely to arrive late on Day 2 or early Day 3 depending on it's strength and the interaction of the aforementioned CME. There is a chance that these features may lose their usual identities should the CME arrive.

Day 4 will then likely see geomagnetic activity decrease back to Quiet levels.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	50	20	5
Strong	G3	No	1	2	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
13/0833	Partial Halo	AR3032 M3 flare	AR3032 NE Limb	1100	15/0600	Glancing blow possible

Figure 2: ENLIL model showing arrival of glancing blow CME

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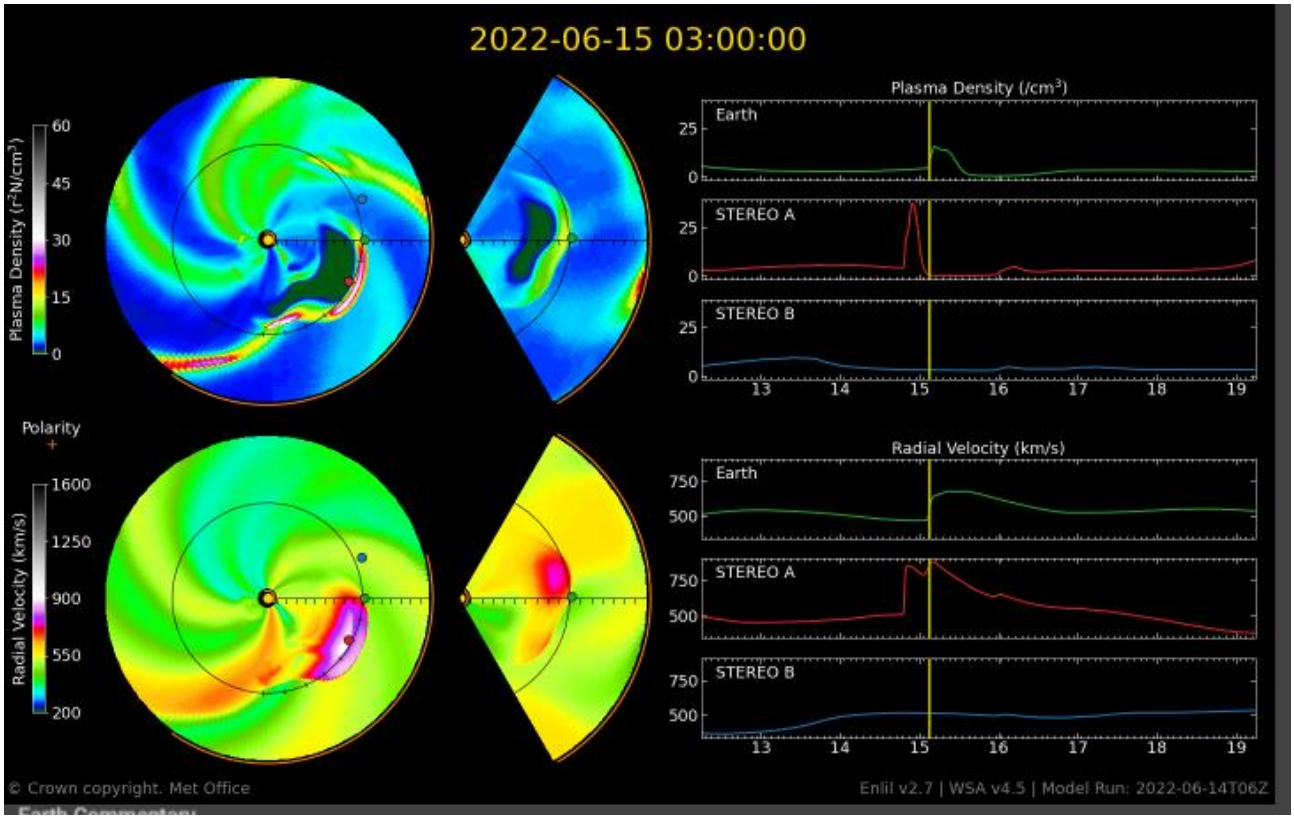

Radio Blackouts - X-Ray Flares:

Solar activity was Low in the last 24 hours, with several C-class flares originating from AR3031 and AR3032/AR3030.

There are currently seven sunspots on the visible disk, the most complex of which is AR3031 in the south centre disk which is exhibiting growth and has developed a Delta spot in recent hours.

Solar activity is expected to be mainly Low, with a chance of further M-class flares, mainly from AR3031 or AR3032. Probabilities of both M-class and X-class flares increase with time due to the presence of bright regions in the EUVI/AIA 195 imagery, suggesting that new sunspot regions may rotate onto the earth-facing disc in the coming days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	35	40	40
Very Active	R3 to R5 X Class	No	2	2	5	5

Figure 3: C8.5 flare from AR3031

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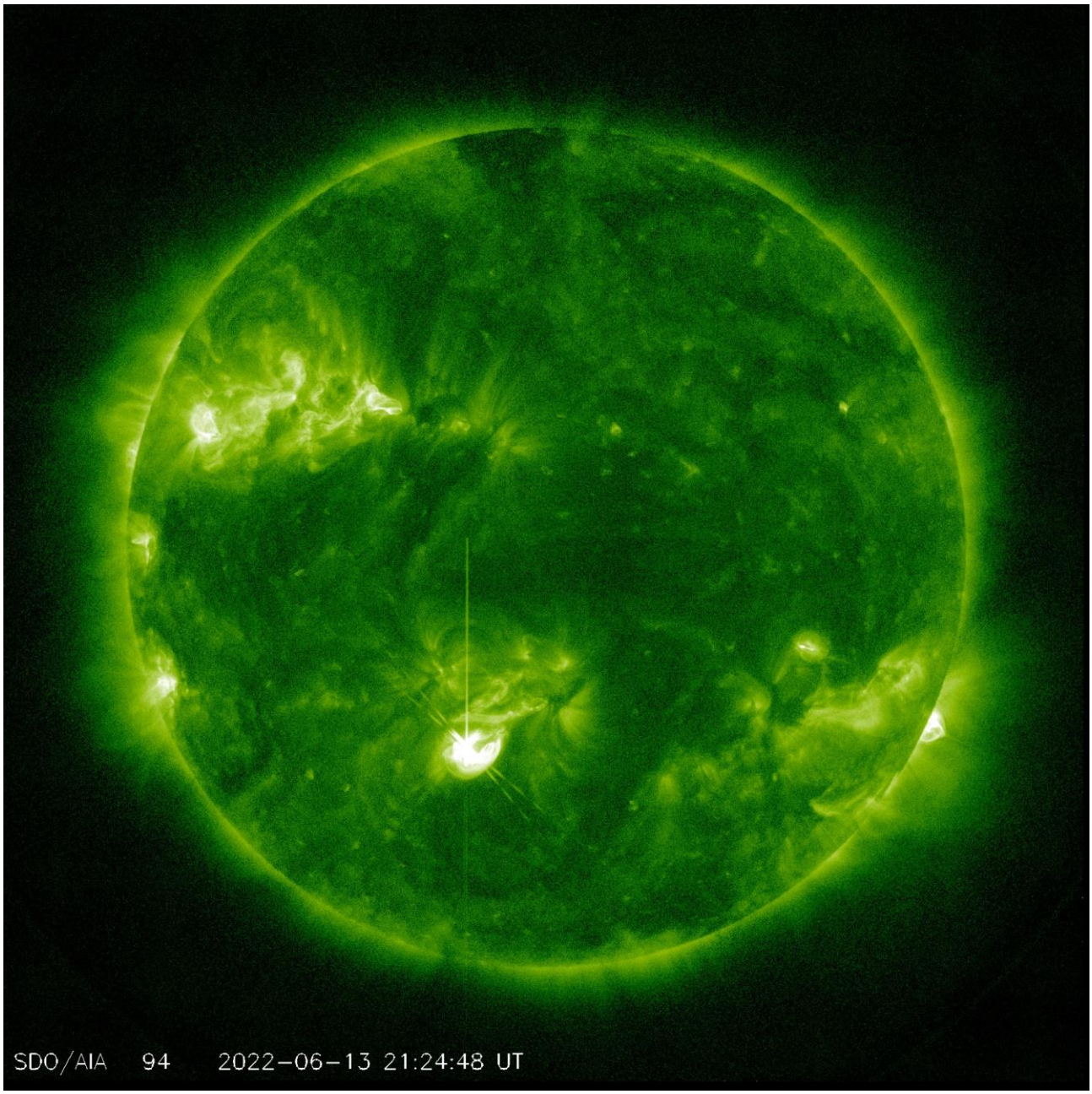

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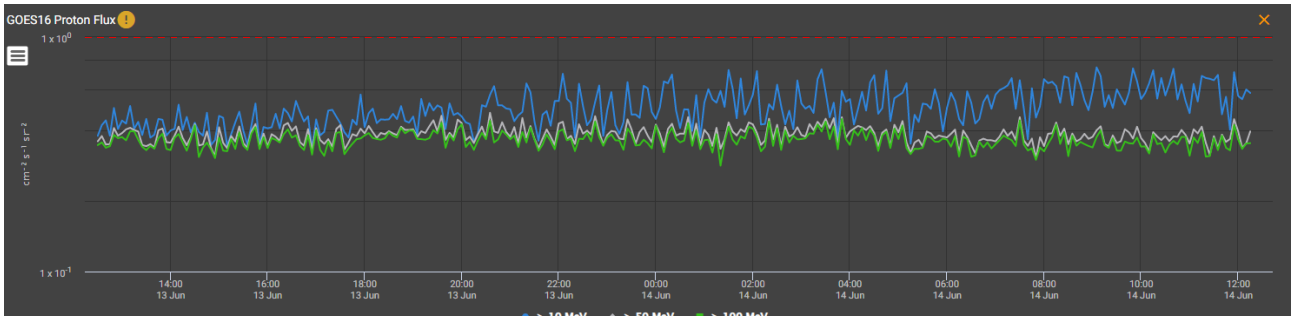
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) was at background levels but became a little above background since around 13/2100 UTC. The risk of a proton storm remains very low.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Proton trace.



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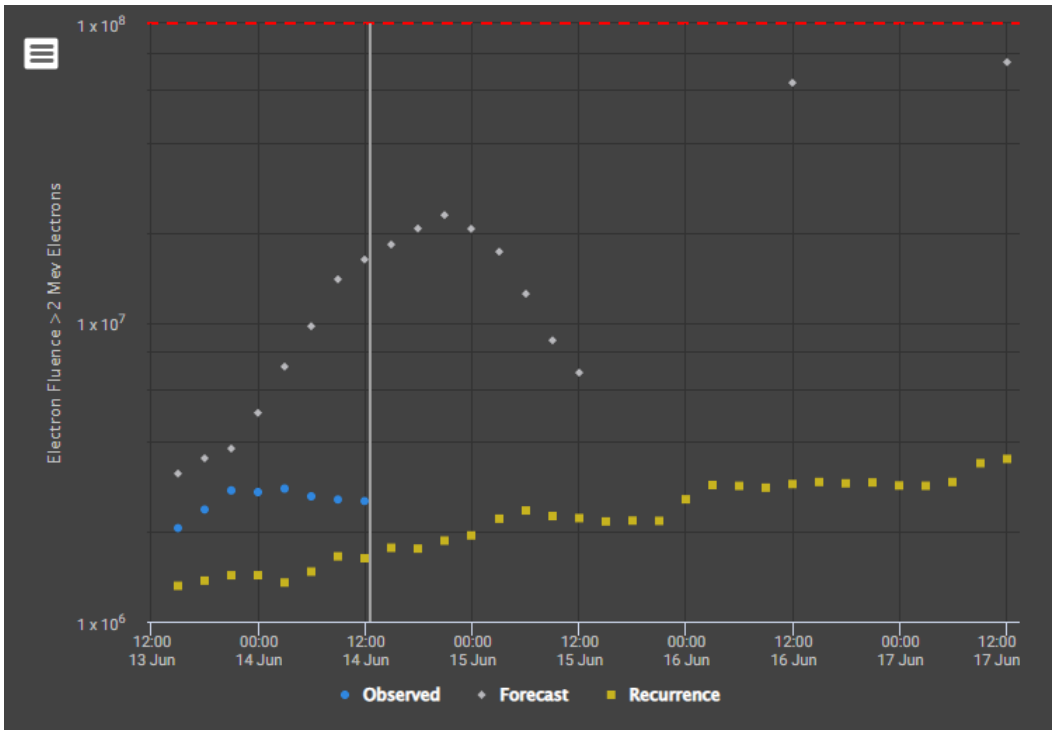
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 is currently at background levels. This is likely to continue due to the arrival of 1xCME and 2xCoronal holes in coming days. The risk of the electron flux becoming moderate or high then increases as the high speed stream weakens, the Van Allen radiation belts may start to charge themselves either later on day 3 or into day 4, therefore marginally increasing the risk of fluence levels reaching the Active (1e8 integrated pfu).

The level of confidence is low as the forecast is essentially based on a glancing blow from the CME that was observed leaving the sun on the 13th. The REFM output is unfortunately not going to be useful on this occasion, as unaware of the CME's risk, but suggests a rise to just below Active levels later in the period, which seems like a reasonable, though over-forecast trend.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	10	20	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	10

Figure 5: REFM Integrated flux forecats and observations.



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